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NATURAL GAS: A LONG BRIDGE TO A PROMISING DESTINATION

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Supporters of efforts to replace hydrocarbons with carbon-free renewable resources as our primary source of electricity often refer to natural gas as a "bridge fuel."[2] That reference reflects a reluctant recognition that renewable resources can not replace hydrocarbons as our primary generating fuel in the near term. It is also reflects a recognition that, while natural gas is a hydrocarbon, it is less damaging to the environment than other fossil fuels. In particular, displacement of coal with natural gas as a generating fuel reduces emissions of greenhouse gases, i.e., carbon dioxide, by about fifty per cent. Thus, the "bridge fuel" metaphor refers to the expectation of many policy makers that we can move in the direction needed to mitigate climate change in the near term by displacing coal with natural gas, but that we will replace all hydrocarbons with carbon-free renewable resources in the longer term.

My goal is to explore and to critique the assumptions that underlie the bridge fuel metaphor. I begin by focusing on the length of the bridge that natural gas is likely to provide. I conclude that the natural gas bridge to carbon-free fuels is likely to be extremely long, at least decades and probably a century. I then explore the question of what we are likely to find at the end of that bridge. Is it metaphorically like the "bridge to nowhere" that the Senator from Alaska famously (or infamously) inserted as an earmark in an appropriations Bill?[3] I conclude that, while the "bridge" will not take us everywhere

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[1] Lyle T. Alverson Professor of Law, George Washington University. I am indebted to David Fontana, Robert Glicksman & Ira Lupu for helpful comments omn a earlier version of this essay.

[2] E.g., Joel Kirkland, Natural Gas Could Serve as A Bridge Fuel to Low Carbon Future, Scientific American (June 25, 2010); John Podesta & Timothy Wirth, Natural Gas: A Bridge Fuel for the Twenty First Century, Center for American Progress (Aug. 10, 2009).

[3] See Ronald Utt, The Bridge to Nowhere: A National Embarrasment The Heritage Foundation Web Memo # 889 (Oct. 20, 2005).

we would like to go, it is likely to take us to a destination that is a major improvement on the status quo measured with reference to any plausible set of national or international goals.

How Long Is the Bridge?

New uses of two old technologies—horizontal drilling and hydraulic fracturing—have enabled the U.S. to increase its natural gas reserves by 75% during the period 2004-2011.[4] The supply of gas from fracturing of shale formations has increased at the rate of 48% per year since 2006, and the Energy Information Administration (EIA) predicts a continuation of that trend for many more years.[5] In the short-term, that increase in reserves has increased deliverable quantities of gas by 14 per cent[6] and allowed us to displace 10 per cent of the coal we were using to generate electricity just three years ago.[7] It has also resulted in a price of gas that is only about thirty per cent of the price of oil and approximately equal to the price of coal.[8] This remarkable change in conditions in the U.S. gas market is likely to yield more significant results in the future. Most experts believe that our gas resource base is now sufficient to meet U.S. demand for over a century and to allow us to use gas as our primary generating fuel for the foreseeable future.[9]

The contrast between the prospects for gas and the prospects for carbon-free renewable resources is stark. It costs two to five times as much to generate electricity through use of renewable resources such as solar and wind as through use of gas.[10]

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[4] Potential Gas Committee, Potential Supply of Natural Gas in the United States (Apr. 27, 2011).
[5] Energy Information Administration, Annual Energy Outlook 2011 (Apr. 2011).
[6] Energy Information Administration, Natural Gas Monthly (Sep. 29, 2011).
[7] Energy Information Administration, Electric Power Monthly (Oct. 6, 2011).
[8] Id.
[9] Energy Information Administration, note 5, supra.
[10] Energy Information Administration, 2016 Levelized Cost of New Generation Resources (2010).

Moreover, because most renewable resources can generate electricity only on an intermittent basis, a unit of electricity generated through use of a renewable resource is worth only about twenty-five per cent as much as a unit of electricity generated through use of gas.[11] The Cape Wind project proposed to be constructed off the coast of Cape Cod illustrates the resulting bleak economics of renewable resources. The project sponsors are not willing to go forward unless they can obtain a long-term contract price of 18.7 cents per kilowatt hour (kwh), escalating at a rate of 3.5% per year.[12] That is on top of a federal subsidy of 2.1 cents per kwh. Adjusting for the much lower value of the intermittent electricity supply Cape Wind would produce, that is equivalent to a gas generation price of 83.2 cents per kwh—at least ten times the price of electricity generated through use of gas.

The economics of solar projects are similarly bleak. Electricity generated through use of solar power is somewhat more valuable than electricity generated through use of wind power because sunny periods correlate better with periods of high electricity demand than do windy periods. That higher unit value is more than offset by the higher unit cost of solar energy, however. Germany and Denmark initially set a price of 58 cents per kwh on electricity generated from solar sources on the basis of their estimates of the price that was needed to induce developers to install solar generating units.[13] Adjusting that price to reflect the lower value of the intermittency of any solar source yields an effective cost that approximates the cost of wind power and that is at least ten times greater than the price of electricity generated through use of gas.

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[11] Paul Joskow, Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies (MIT Website Feb. 9, 2011).
[12] SNL Energy Electric Utility Report 24-25 (Nov. 29, 2010).
[13] See Marcus Maedi, The German FIT for Renewable Energy—A Bargain, Renewable Energy World. Com (Apr. 14, 2008).

Renewable resources have major disadvantages in addition to their high cost. They require installation of thousands of miles of new transmission lines. It is extremely difficult to obtain both the regulatory approvals needed to site transmission lines and the financing needed to construct transmission lines.[14] The intermittent nature of electricity generated by renewable resources also poses serious risks to the continued ability of U.S. utilities to provide reliable electricity service.[15] Moreover, renewable resource projects have serious adverse environmental effects that make them controversial.[16] Ironically, the local affiliates of the same national environmental advocacy groups that support programs to replace hydrocarbons with carbon-free renewable alternatives in the abstract oppose many of the actual renewable resource projects that have been proposed to implement those programs.[17]

Efforts to develop electricity projects that use renewable resources to generate electricity and to market the electricity produced by such projects are entirely dependent on the continued availability of extraordinarily generous federal and state subsidies and state renewable resource portfolio mandates. Those subsidies and mandates are unlikely to continue. Many European nations are ahead of the U.S. in their attempts to encourage use of renewable resources to replace hydrocarbons in the electricity sector. They are also ahead of the U.S. in facing taxpayer and consumer backlash caused by the high cost of subsidies and mandates. Every European nation that once used subsidies and mandates to encourage development of renewable resources either reduced those subsidies and

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[14] See Richard Pierce, The Past, Present, and Future of Energy Regulation, 31 Utah Env. L. Rev. 291, 302 (2011).

[15] North American Reliability Commission, Ensuring a Reliable Bulk Electricity System (May 20, 2008).

[16] Robert Glicksman, Solar Energy Development on the Federal Public Lands: Environmental Trade-Offs on the Road to a Lower-Carbon Future, forthcoming in San Diego J. Energy & Climate Law (2012).

[17] See. e.g., Robert Glennon & Andrew Reevews, Solar Energy's Cloudy Future, 1 Ariz. J. Envtl. L & Policy 91, 116 (2010).

mandates significantly or abandoned them completely over the three-year period beginning in 2008.[18] Spain and Portugal, the nations with the highest proportion of their electricity supply generated from wind and solar sources, took the extraordinary step of reneging on the long-term commitments they made to renewable resource projects by *retroactively* eliminating their subsidies.[19] Spain and Portugal saved many billions of dollars by taking that action. It was one of the critical steps in the efforts of both countries to avoid defaulting on their sovereign debt.

Given the financial and fiscal crises that now afflict the U.S., it is highly unlikely that either the federal government or most states will choose to retain their extraordinarily expensive subsidies and mandates for renewable resources. Thus, I am confident that there will be a critical need to use gas as a bridge fuel for the indefinite future. Fortunately, the gas resource base appears to be adequate to that task for at least the next century.

Where Does the Bridge Lead?

The policy makers who coined the phrase "bridge fuel" believe both that the "bridge" will be relatively short and that it will lead to replacement of all hydrocarbons with carbon-free renewable resources. In the prior section, I explained why I believe that the "bridge" that natural gas must create will be long—at least many decades and probably a century. I will turn next to the question of what lies on the other side of that bridge. It is possible that technological developments over the next several decades will create a situation in which carbon-free renewable resources will become economically

[18] Eric Rosenblum, Solar Grinch: Spain Does the Unthinkable, Thestreet. Com (Dec. 23, 2010).
[19] Id.

viable and in which developers of renewable resource projects will be able to overcome the other formidable obstacles to replacement of hydrocarbons with renewable resources. It is more likely, however, that technological breakthroughs will create an environment in which natural gas remains the best available means of meeting our needs for electricity for many more decades after we cross the present long "bridge." In other words, the long natural gas "bridge" is likely to lead to more natural gas.

Returning to the metaphor inspired by the earmark the Alaskan Senator inserted in an appropriations Bill, the gas "bridge" will not be a "bridge to nowhere." It is unlikely to lead to the destination that the policymakers who coined the phrase expect—replacement of hydrocarbons with carbon-free renewable resources. It is likely to lead to a destination, however, that is a dramatic improvement on the status quo in virtually all respects. Displacement of coal and oil with natural gas as a generating fuel will improve both the economy and the environment.

In the U.S., replacing coal with gas would reduce total emissions of green house gases attributable to electric generation by 45 per cent.[20] That is well-short of the 80 per cent reduction in global emissions that climate scientists believe to be needed to mitigate global warming, but it is a major step in the right direction. If we combine that step with the other steps that make sense in their effects on both the economy and the environment—a carbon tax[21] and real-time pricing of electricity[22]—we will have a reasonable chance of meeting our climate goals. Replacing coal with gas will have other significant environmental benefits as well, e.g., elimination of the tens of thousands of

[20] International Energy Agency, Greenhouse Gas R&D Program: CO2 Emissions Data Base (2009).
[21] See Richard Pierce, supra. note 14.
[22] Richard Pierce, A Primer on Demand Response and a Critique of FERC Order 745, forthcomiong in George Washington J. Energy & Envtl L (2012).

premature deaths and hundred of thousands of illnesses in the U.S. each year that are caused by inhalation of pollutants emitted by coal-fired generating plants.[23] Moreover, we could extend the benefits of the U.S. gas boom to the transportation sector by increasing the direct use of compressed natural gas in vehicles and/or by increasing the indirect use of natural gas by increasing the number of vehicles that are powered by gas-generated electricity.

The gas boom in the U.S. can also produce major improvements in other respects. It has created a situation in which the U.S. can reduce dramatically its dependence on energy from insecure foreign sources.[24] In fact, North America is in the process of becoming a major *exporter* of gas. The U.S. and Canada are about to begin exporting large quantities of gas to Asia.

Economic conditions have improved significantly in the states where the drilling is taking place. Those states include Pennsylvania, which has become the second largest producer of natural gas in the U.S. over the past three years. Pennsylvania estimates that gas drilling has increased economic activity in the state by billions of dollars and has created thousands of new jobs in the state over the last three years.[25] Ohio is expected to enjoy a similar gas-based economic boom in the near future.[26] New York has the potential to enjoy similar economic benefits when, and if, it lifts its moratorium on horizontal drilling and hydraulic fracturing.[27]

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[23] Michael Greenstone & Adam Looney, A Strategy for America's Energy Future Illuminating Energy's Full Cost, Brookings Institution (May 2011).
[24] Kenneth Medlock, Amy Jaffe & Peter Hartley, Shale Gas And US National Security (Baker Institute 2011).
[25] Governor's Marcellus Shale Advisory Commission Report (July 22, 2011).
[26] Jack Kleinheinz & Russ Smith, Ohio's Natural Gas and Crude Oil Exploration and Production Industry and the Emerging Utica Gas Formation: Economic Impact Study (Sep. 2011).
[27] Timothy Considine, Robert Watson & Nicholas Considine, The Economic Opportunities of Shale Energy Development, Manhattan Institute for Policy Research (June 2011).

The gas boom and its beneficial effects will be felt far beyond U.S. borders. The Energy Information Administration (EIA) has identified 48 shale gas formations in 32 countries that have the potential to yield new gas supplies comparable to those that have nearly doubled U.S. gas reserves in only six years.[28] Large new basins are being discovered as I write this essay. Thus, for instance, on September 21, 2011, a small gas producer announced the discovery of a new basin in the UK that has the potential to satisfy all of the UK's gas demand for 64 years.[29] Horizontal drilling and hydraulic fracturing in basins outside the US can at least triple global gas supplies.[30] That, in turn, will reduce dramatically the price of gas in Asia and Europe, thereby simultaneously improving the global economy and the global environment.[31] The International Energy Agency (IEA) predicts that gas will displace coal as the dominant source of energy in the world by 2030.[32]

China is poised to be a particularly large beneficiary of the shale gas boom. EIA has identified several promising basins in China.[33] IEA predicts that China will consume more gas than the entire EU by 2030.[34] Since China is the largest source of greenhouse gas emissions and by far the largest source of increases in greenhouse gas emissions,[35] China's ability to replace coal with inexpensive gas as its primary electricity generating fuel has the potential to move the world a long distance toward the goal of effectively

[28] Energy Information Administration, World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States (Apr. 2011). See also International Energy Agency, Are We Entering a Golden Age of Gas? (2011).
[29] Guy Chazan, UK Gets Big Shale Find, Wall Street Journal (Sep. 22, 2011).
[30] Kenneth Medlock, Impact of Shale Gas Development on Global Gas Markets, Natural Gas & Electricity 22 (2011).
[31] Id.; IEA, supra. note 28. See also Susan Sakmar, The Global Shale Gas Initiative: Will the United States Be the Model for Shale Gas Development Around the World? 33 Houston J. Int. L. 369 (2011).
[32] IEA, note 28, supra.
[33] EIA, note 28, supra.
[34] IEA, note 28, supra.
[35] EIA International Energy Statistics (2011).

mitigating global warming. The shale gas boom will also have significant beneficial effects on geopolitical conditions by, for instance, reducing Russia's leverage over Europe attributable to Gazprom's dominance of the European gas market, reducing Iran's leverage over India attributable to India's heavy reliance on energy supplies from Iran, and eliminating completely the risk that Russian President Vladimir Putin will be successful in his efforts to create a natural gas version of the OPEC cartel.[36]

The remarkable increase in the U.S. natural gas supply that has occurred over the last five years and that has the potential to yield major global benefits for many decades has been attributable to new applications of old technologies. In the meantime, Japan and Korea have invested heavily in an effort to develop a new technology that would have beneficial effects on the U.S. and global gas markets for many more centuries. Japan and Korea are in the process of devising means of extracting natural gas (methane) from methane hydrates. Methane hydrates are found in marine sediments around the world. As described by the United States Geological Survey: "The worldwide amounts of carbon bound in gas hydrates is conservatively estimated to total twice the amount of carbon to be found in all known fossil fuels on earth."[37]

Japan has committed 127.5 million dollars to a project that will begin with a test well in 2013.[38] Japan expects to begin actual gas production from methane hydrates by 2018. Korea has embarked on a similar program.[39] If Japan and Korea are successful, gas production from methane hydrates will begin on a commercial scale long before we

[36] Coming Soon to a Terminal Near You: Shale Gas Will Make the World a Cleaner and Safer Place, The Economist 51 (Aug. 6, 2011); Medlock, note 30, supra.
[37] USGS Marine and Coastal Geology Program, Gas (Methane) Hydrates—A New Frontier (Aug. 3, 2011).
[38] Sadao Nagakubo, Nao Arata, Itsuka Yabe, Hideo Kobayashi & Koji Yamamoto, Environmental Assessment Study on Japan's Methane Hydrate Program, Department of Energy, Methane Hydrate R&D Program Newsletter, vol. 10 (2010).
[39] Sung-Rock Lee, 2nd Ulleung Basin Gas Hydrate Expedition: Findings and Implications, Department of Energy, Methane Hydrate R&D Program Newsletter, vol. 11 (2011).

exhaust the dramatically expanded gas reserves that have become available as a result of horizontal drilling and hydraulic fracturing of shale formations. Gas from methane hydrates is capable of meeting both U.S. and global demand for generating fuels for many centuries.

Conclusion

I am well aware that there are important conditions that must be satisfied to realize my rosy scenario. The availability of the initial century-long natural gas "bridge" to the future is dependent on the ability and willingness of gas producers to take the steps needed to satisfy citizens and governments that horizontal drilling and hydraulic fracturing of shale formations can be accomplished with tolerably low environmental costs.[40] The happy destination I predict at the end of that long bridge—additional centuries of abundant, inexpensive, and environmentally benign natural gas--depends on the success of Japan and Korea in devising means of producing gas from methane hydrates at reasonable economic and environmental cost. I believe, however, that the conditions required for creation of the century-long bridge are highly likely to be satisfied. I also believe that there is a reasonable chance that the conditions for creation of the many centuries of the availability of cheap and environmentally benign natural gas thereafter will also be realized. My rosy scenario is far more realistic than the picture of the future painted by those who see hydrocarbons replaced by windmills and solar arrays. That is a highly implausible scenario.

[40] For a detailed discussion of the steps needed to assure that shale gas is produced in an environmentally sound manner, see Department of Energy, Secretary of Energy Advisory Board, Shale Gas Production Subcommittee 90-Day Report (Aug. 18, 2011).